

EDITORIAL

Exercise and the immune system: implications for elite athletes and the general population

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As the quadrennial sporting jamboree that is the summer Olympic Games fast approaches, athletes from all over the world will be training hard towards achieving a lifetime's ambition. While we at home marvel at athletes' abilities to perform faster, higher and stronger than ever before, what many will not realise is that intense exercise has dramatic effects on the host immune system. Indeed, strenuous exercise elicits immunological changes similar to many clinical stresses such as trauma, burns, surgery and sepsis. Specifically, a substantial body of work accumulated over the last 20 years has shown that intense endurance exercise, such as running, swimming, cycling or rowing, results in a profound leukocytosis due to increases in the numbers of neutrophils, T and B lymphocytes, and NK cells in the systemic circulation.^{1,2} Furthermore, in the post-exercise recovery period a marked alteration in the proportions of circulating immune cells is observed, with several immune cell populations decreasing to below pre-exercise levels. Additionally, the functions of many of these immune cell types are also altered following exercise.^{1,2} These changes have led to the idea that this recovery period from intense exercise presents a window of opportunity for infectious agents to gain a foothold, although convincing epidemiological data for this are lacking.

However, while the Olympic Games represent the pinnacle of athletic endeavour, it is important to note that regular (3–4 times per week), moderate-intensity exercise has a remarkable range of salutary health effects and probably prevents a great many of the diseases that now threaten mankind globally; for example, cardiovascular disease and type 2 diabetes. The reviews contained within this Special Feature of *Immunology and Cell Biology* examine several facets of the remarkable effects that exercise has on the immune system.

For the elite athletes who will be competing in the Rio Olympics, infection and illness raise two principal concerns: first, illness around competition time is likely to have a direct impact on performance, and second, illness during the lead-up to competition disrupts and limits training. Dietary supplementation is a common approach to minimise incidences of infection, and in his review Gleeson³ discusses the evidence for the numerous nutritional and dietary strategies that athletes can use to maintain a robust immune system. The most common type of illness that athletes suffer from is upper respiratory illness (URI). In their review Gleeson and Pyne⁴ discuss the causes of URI in athletes, the use of biomarkers to identify at-risk athletes and the nutritional strategies that can reduce the incidence of URI. Athletes often have to perform at their physical limits in environments that can impose further physiological stress. For example, temperature, humidity and altitude are all factors that can impose further stresses

on the body, and, in their review, Walsh and Oliver⁵ discuss how environmental stress has significant impacts on immunity and URI.

While the great majority of us will not compete in sport at the Olympic level, we have all experienced the muscle soreness that follows unaccustomed physical activity: this might be the first run following a new year's resolution or weeding the garden. It is well known that immune cells are recruited to, and inflammation occurs at, sites of myofibre damage and many treatments aim at reducing this immune and inflammatory response. However, in her review, Chazaud⁶ discusses the evidence that in fact this immune response to muscle damage is critical for proper tissue repair.

While the positive health effects of exercise are probably mediated via a number of mechanisms, it appears that one principal effect by which exercise can mediate positive health effects is via the modulation of the immune system. In their review, Karstoft and Pedersen⁷ discuss some of the mechanisms by which exercise exerts its anti-inflammatory and metabolism-improving effects.

The intestinal tract is home to a large and diverse array of microorganisms collectively referred to as the gut microbiome. Research over the last several years has demonstrated the remarkable role that the gut microbiome plays in regulating host immunity and metabolism, and disruptions to the gut microbiome can lead to the development of numerous chronic inflammatory diseases. In their reviews, Mika and Fleshner⁸ along with Woods and his colleagues⁹ discuss the role that exercise can play in shaping the gut microbiome and the positive effects this may have in promoting metabolic health and in preventing chronic inflammatory disease.

Collectively, these reviews present a fascinating insight into how exercise influences the host immune system.

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